Section 5: Likelihood, Timing & Magnitude of Recovery

Estimating the likelihood, timing and magnitude of recovery volumes through modeling is an essential component of recovery planning. Recovery modeling takes into account water supply and demand factors to estimate when recovery may occur. The recovery volume is a function of both Colorado River supply and Arizona demand for Colorado River water, both on-River and within the CAP service area. This section discusses the revised 2014 supply and demand assumptions, updated recovery modeling, and associated recovery results.

Factors Affecting Recovery

The need for recovery can result from shortages in the Colorado River supply or a request by Nevada for the creation of Intentionally Created Unused Apportionment (ICUA). Whether or not recovery is triggered by a shortage is dependent on the magnitude of the shortage and the demands by Colorado River water users in Arizona at the time of shortage. Therefore, recovery of AWBA LTSCs will be required when the reduction in supply intersects demand by CAP pools and on-River P4 M&I users for which AWBA has firming responsibilities.

Supply Factors

Colorado River supply each year is affected by reservoir storage, runoff from snowmelt and precipitation, upper basin consumptive use, and policies governing reservoir operations. Although hydrology and consumptive uses change from year to year, the most significant operational change since the 2014 Plan is the adoption of the Drought Contingency Plans (DCPs) for the Upper and Lower Basin that went into effect in 2019. DCP is a set of agreements designed to protect the Colorado River system through increased conservation and reductions at higher elevations. The DCP acts as an overlay to the 2007 Lower Basin Shortages and Coordinated Operation of Lake Powell and Lake Mead (2007 Interim Guidelines) and accordingly will operate through December 31, 2026.

The Lower Basin DCP (LBDCP) established earlier and deeper reductions by requiring additional contributions from Arizona (Table 4) and Nevada, along with new contributions from California and the United States. Arizona and Nevada contributions are in addition to the shortage reductions set forth by the 2007 Interim Guidelines. In addition, the Republic of Mexico has also agreed to water savings under a Binational Water Scarcity Contingency Plan (BWSCP) pursuant to Minute 323 signed in September 2017.

While LBDCP allows the conversion of existing Intentionally Created Surplus (ICS) towards LBDCP contribution, the modeling results presented in the Section assumes the contributions will be satisfied through reductions in available supply. For the purposes of recovery planning, operational rules for the DCP, the 2007 Interim Guidelines and the BWSCP are all extended through 2045.

Table 4 Arizona Shortage Reductions under 2007 Interim Guidelines and Additional LBDCP Contributions

Lake Mead Elevation (ft.)	Tier	2007 Interim Guidelines (AF)	LBDCP Contribution (AF)	Total (AF)
≤1090>1075	Tier 0	0	192,000	**192,000**
≤1075>1050	Tier 1	320,000	192,000	**512,000**
≤1050>1045	Tier 2a	400,000	192,000	**592,000**
≤1045>1025	Tier 2b	400,000	240,000	**640,000**
≤ 1025	Tier 3	480,000	240,000	**720,000**

Source: 2007 Interim Guidelines and LBDCP (2019)

Reductions to Arizona as shown in Table 2 above are apportioned among fourth priority users based on the 2006 Director's Shortage Sharing Recommendations. The Recommendations outline a step-by-step approach in which the supply available to P4 users is first determined by subtracting P1-3 consumptive uses from supplies available to Arizona. Shortage reductions are then shared between on-River P4 users and CAP, using a formula that is based on the total P4 supply prior to shortage reduction, and on-River P4 supplies based on the use of their entitlements. Because current on-River P4 use is far below the full combined entitlement of 164,652, CAP water users will bear the full brunt of the reductions to Arizona in the near term.

Demand Factors

On-River Demand

High priority P1-3 users are not directly impacted by shortage reductions to Arizona's Colorado River supply. These uses are primarily agricultural and have not exhibited an upward trend in use over the past decade. For this Update, the ten-year average (2009-2018) consumptive use was used as the starting point for the three P1-3 growth projection scenarios: 1) no increase; 2) 0.1% annual increase and 3) 0.5% annual increase (**Figure 2**). The 0.1% increase scenario was selected as the baseline for the purposes of this update.
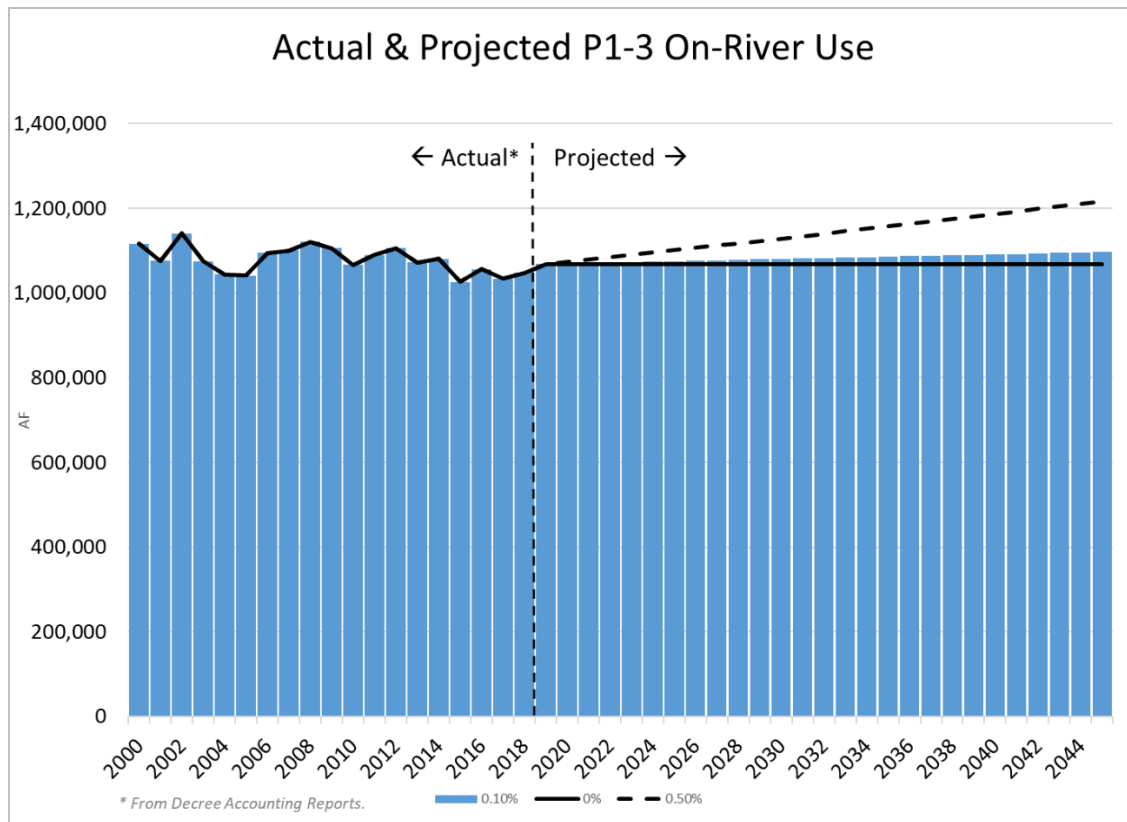
Figure 2 Actual and Projected On-River P1-3 Consumptive Use for three scenarios: (i)use held constant; (ii) 0.1% annual increase; iii) a 0.5% annual increase

In the 2014 Plan, On-River (P1-4) contract use was projected to increase to approximately 1.22 MAF by 2045.[1] As explained above, P4 contracts in aggregate are underutilized, but there is recognition that P4 demands may grow in the future.

P4 on-River contracts are a combination of agricultural and municipal uses. In the 2014 Plan, on-river P4 contract use was projected to be 92,000 AF by 2045. P4 on-River contract use has been lower than these projections with a 2014-2018 average use of 57,534 AF. As a result, the five-year average (2014-2018) was used as a starting point with a 1% projected increase for M&I uses and agricultural use remaining constant (**Figure 3**).

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[1] This is the same assumption that ADWR called "Scenario A" in it the NIA reallocation process modeling (2012) showing mainstem uses growing at a moderate rate.
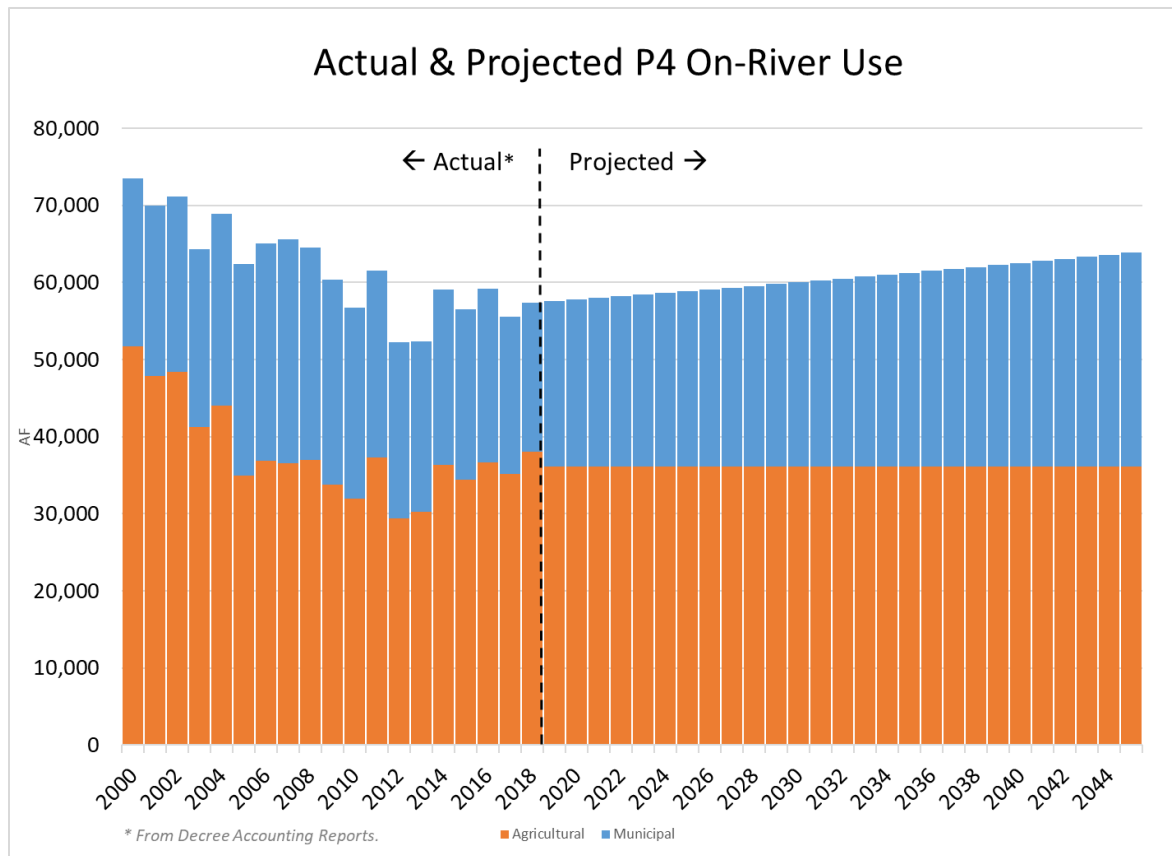
Figure 3 Actual and Projected Agricultural and Municipal On-River P4 Consumptive Use

CAP Demand

Projections of CAP demand were developed based on the total available delivery supply; the four long-term contract priority pools;[2] the Agricultural Settlement Pool (through 2030); and Other Excess. The updated modeling was based on a starting point of 2020 water orders, and an assumption that the full CAP long-term contract volume of 1.415 MAF would be allocated and used by 2045 (**Figure 4**). In the 2014 Plan, full utilization by 2035 and 2045 was modeled. The more specific timing of the NIA reallocations for M&I uses, the enforceability of the White Mountain Apache Tribe water settlement, and future Tribal water settlements was also updated from the 2014 Plan.

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[2] The CAP long-term entitlements are grouped into four priority types; P3, Indian, M&I and NIA (listed from highest to lowest priority).

CAP Build-up by 2045
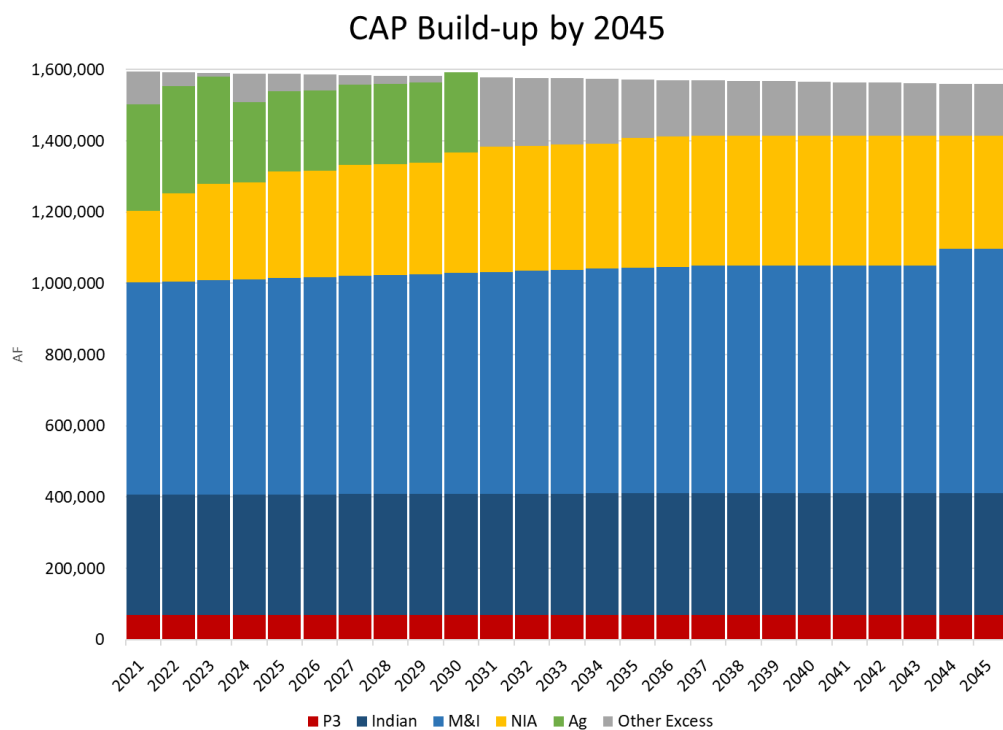
Legend: P3, Indian, M&I, NIA, Ag, Other Excess

Figure 4 CAP Build-Up Demand Schedule

Interstate Requests

Southern Nevada Water Authority (SNWA) is reviewing its ten year plan for Intentionally Created Unused Apportionment (ICUA) requests, which would generate the need for recovery. Currently, the AWBA holds 613,846 AF of LTSCs for SNWA of which approximately 600,000 AF must be recovered by the early 2060s. For planning purposes, AWBA and CAWCD anticipate SNWA will request a minimum of 2,500 AF of ICUA development per year beginning in 2025 pursuant to the Arizona Water Company Agreement. ICUA requests beyond that, including shortage requests, as defined in the Third Amended Agreement[3]. The focus of this recovery will be in the Pinal AMA where a majority of interstate credits are located.

Modeling Approach

The supply and demand factors described above are quantified and evaluated using two different models - the Bureau of Reclamation's Colorado River Simulation System (CRSS) and a custom Joint Recovery Model (JRM).

The CRSS model generates a range of future Colorado River supplies available to Arizona by incorporating basin hydrology, Upper Basin demands and current reservoir operating rules. Recovery modeling for the 2014 Plan used Colorado River direct natural flow (1906-2010) hydrology and analyzed scenarios based on different intrastate and interstate demand assumptions. This Update incorporates more recent hydrology, and DCP operating rules. Some of the key assumptions used in the CRSS model for this Update are outlined in **Table 5** below. To

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[3] Third Amended and Restate Agreement for Interstate Water Banking (2013)

prepare for a wide range of future hydrologic conditions, and to explore the sensitivity of Lake Mead elevations to a range of variables explicit in the CRSS model, the modeling for this Update explored scenarios using different projected Upper Basin demands and basin hydrology. For this Update, two different Upper Basin demand projections were considered—the demand projection included in the CRSS model, and a scenario using a 15% reduction to that CRSS demand projection---and two different hydrologies were evaluated—the Colorado River direct natural flow (1906-2017) hydrology, and a scenario using stress test hydrology (1988-2017). A list of additional assumptions can be found in **Appendix E**.
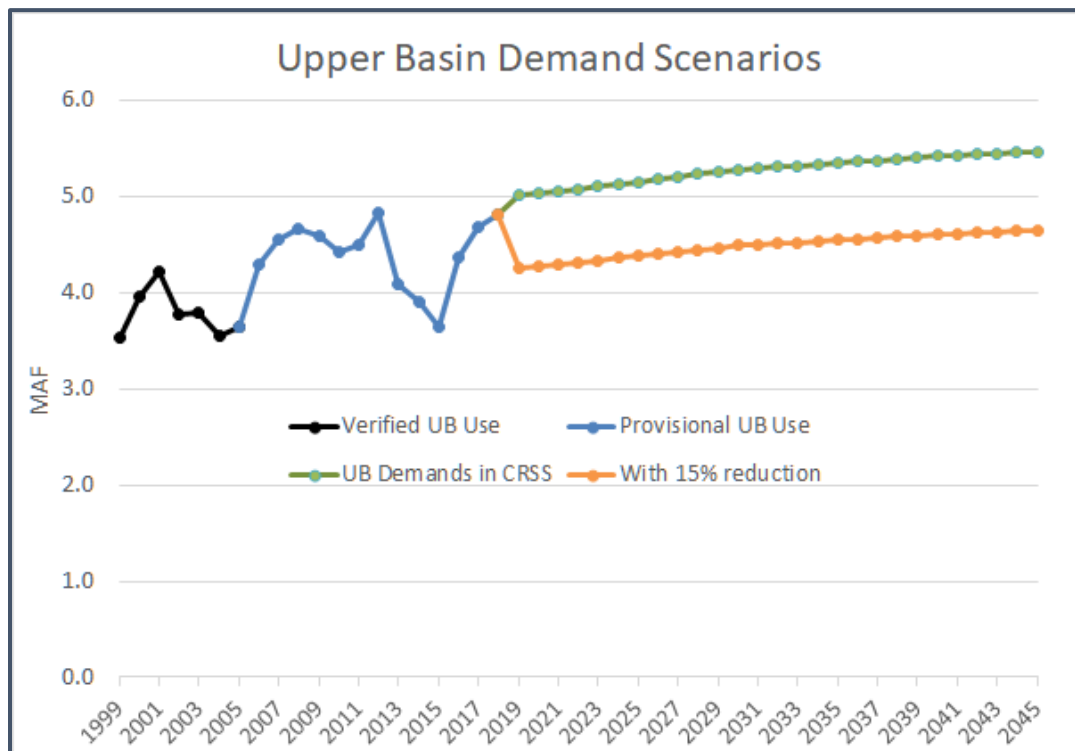

Figure 5 Upper Basin Demand Scenarios

Using these assumptions, CRSS generates projections of future Colorado River system conditions, including elevations of Lake Mead and supply available to Arizona.

Table 5 Key Modeling Parameters & Assumptions that affect Arizona's Colorado River Supply

Modeling Parameters	Modeling Assumptions
Basin Hydrology	Observed Record (1906-2017)
Upper Basin Demands	"As-is" in the August (December Update) 2019 model
Operation of Yuma Desalting Plant	No
Mexico Shortage Sharing	Minute 323
Reservoir Operations	2007 Interim Guidelines and DCP, extended through the planning period
Initial Reservoir Condition	August 2019 model with December model correction

These outputs from CRSS, specifically Lake Mead elevations and thereby the supply available to Arizona are then provided as input to the JRM. The JRM calculates the supplies available to Arizona and determines when the supplies may not meet on-River and CAP demands. That determines the portions that are firmed by the AWBA and evaluates the impacts to the AWBA firming requirements.

Modeling Results

Since the 2014 Plan, updated modeling shows larger recovery volumes for the CAP M&I priority pool due to greater supply reductions resulting from the implementation of LBDCP and an increase in demand in the CAP Indian and M&I priority pools. The volume of CAP NIA priority recovery for the AWBA's Indian firming responsibilities is similar to the 2014 Plan, but the probability has grown due to the increased utilization rate of higher priority supplies.
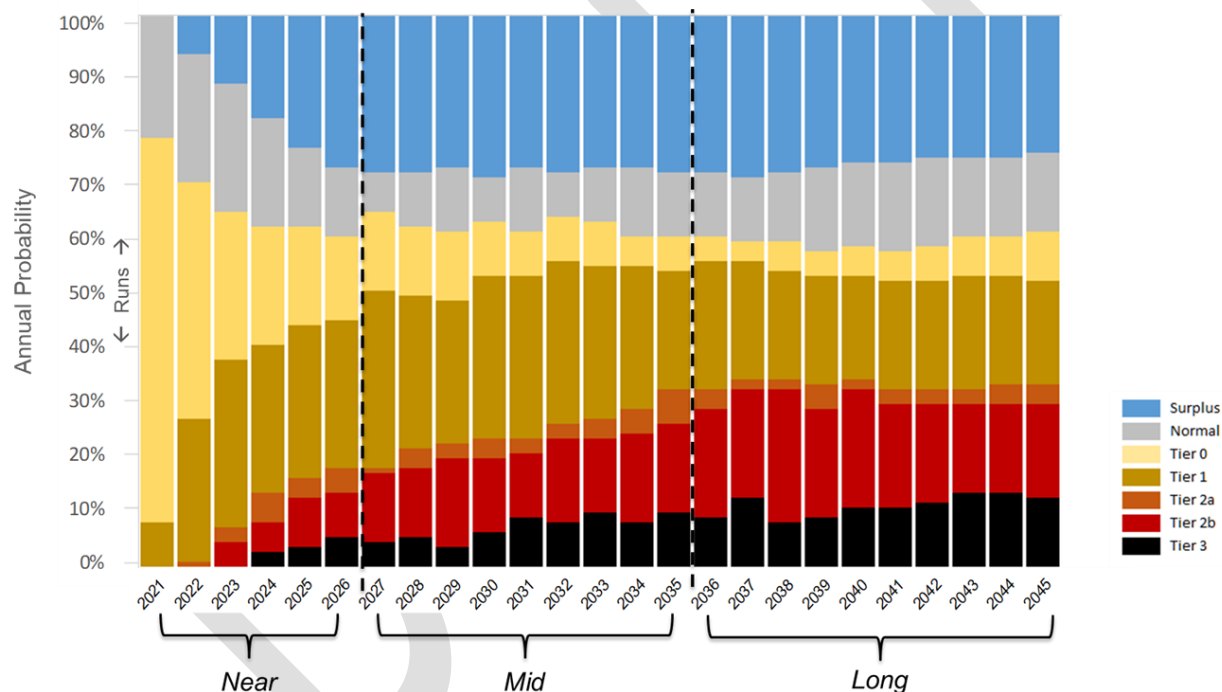

Figure 6 Annual Probabilities of River Condition (Shortage Tier, Normal or Surplus)

The chart of annual probabilities using the 112 Direct Natural Flows hydrologic traces, along with the "As-Is" CRSS Upper Basin demands is shown in **Figure 6**. These results clearly show the increased risk of deeper shortages through time. While the annual probabilities are useful in identifying trends, they can also mask some of the effects of the underlying hydrology, so it can also be helpful to evaluate the likelihood of occurrence over a period of time. **Table 6** was generated by selecting the minimum elevation for each model run (i.e., hydrologic trace), by planning period, and then calculating the probabilities for those 112 results. This approach shows the risk associated with experiencing a particular shortage level during each planning period, irrespective of the particular year it occurs. For instance, in the Mid-term there is a 71% likelihood of dropping below

1,075' (i.e., Tier 1 or worse) at least once sometime during that nine year period, and a 25% likelihood of dropping below 1,025' (Tier 3).

Table 6 Probability of Dropping Below Defined Lake Mead Elevations at Least Once During a Planning Period.

Lake Mead Elevation	Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
<= 1,090'	Tier 0 or greater	86%	75%	73%
<= 1,075'	Tier 1 or greater	55%	71%	68%
<=1,050'	Tier 2a or greater	22%	47%	50%
<= 1,045'	Tier 2b or greater	17%	44%	49%
<= 1,025'	Tier 3	7%	25%	34%

Three additional scenarios with variations in hydrology and Upper Basin demand are included in **Appendix F**. Note that these variations in hydrology and Upper Basin demands have a significant impact on the likelihood and timing of shortages, but not on the magnitude of impact at a given shortage tier. For instance, the scenario using the 15% reduction in projected Upper Basin demand lowers the probability of a Tier 3 shortage, but the impact of the 720 KAF reduction in a given year to on-River and CAP supplies would be identical to the other scenarios.

The probabilistic results from the initial scenario were then used to calculate impacts to each of the supplies that the AWBA has firming responsibilities for. The following graphs depict the AWBA On-river, NIA and M&I recovery volumes and probabilities through the planning period. Shading of the graphs indicate the underlying probabilities for the annual recovery volume that would be necessary and the dashed lines represent the LBDCP Tiers. Very pale blue represents incidence of lower number of hydrologic traces that show shortage and consequently a lower probability of recovery while the darker blue indicates larger number of hydrologic traces that show shortages and therefore higher probabilities for recovery. To further aid in the discussion of the results as well as future planning efforts, the planning horizon was divided into three different periods: Near-Term (2021-2026), Mid-term (2027-2035) and Long-term (2036-2045). In addition, with DCP now effective, recovery modeling results are shown in this Update in relation to the LBDCP tiers.

On-River P4

Modeling results for On-river P4 municipal users show recovery volumes and probabilities through the planning period (**Figure 7**). The magnitude and likelihood of recovery increases through the planning period as the use of P4 contracts increases. There is no On-River recovery in a Tier Zero or 1 or 2a. As deeper reductions in the supply occur, the probability for potential recovery increases in the mid- and long-term planning periods, though the volumes are relatively low.
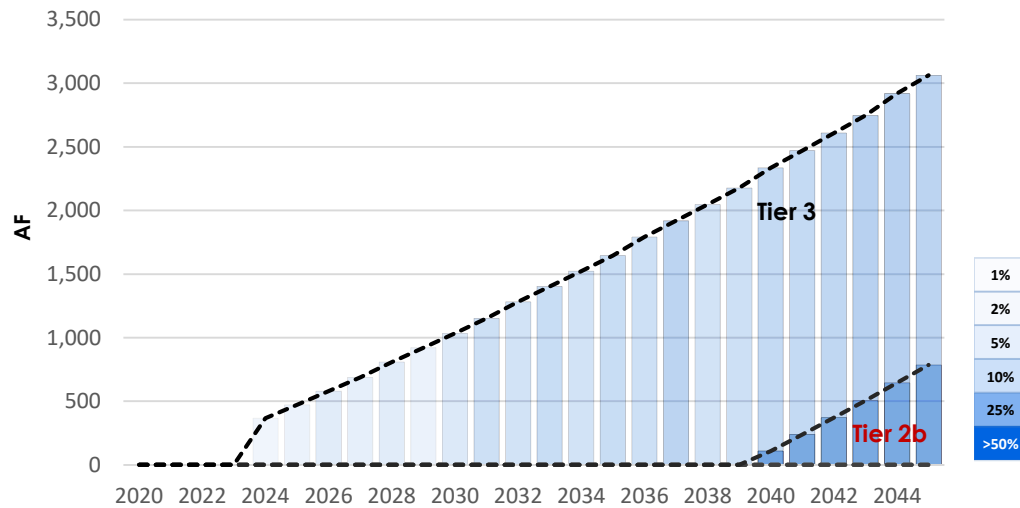
Figure 7 On-River P4 Recovery Volume and Associated Probabilities

The potential maximum recovery volumes through the planning period are low (**Table 7**). The maximum recovery volumes reach 1,900 AF in the mid-term and 3,500 AF in the long-term.

Table 7 Maximum Annual Recovery Volume for the On-River P4 Municipal Users, by Shortage Tier and Planning Period

Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
0	0	0	0
1	0	0	0
2a	0	0	0
2b	0	0	800
3	600	1,600	3,100

NIA

Modeling results for NIA-priority users show recovery volumes and probabilities through the planning period (**Figure 8**). The magnitude and likelihood of recovery increases through the planning period as the use of CAP long-term entitlements increases. Only a portion of the NIA pool used for Tribal settlements is firmed. The maximum total firming by the AWBA is 23,724 AF with the finalization of all future Tribal settlements.
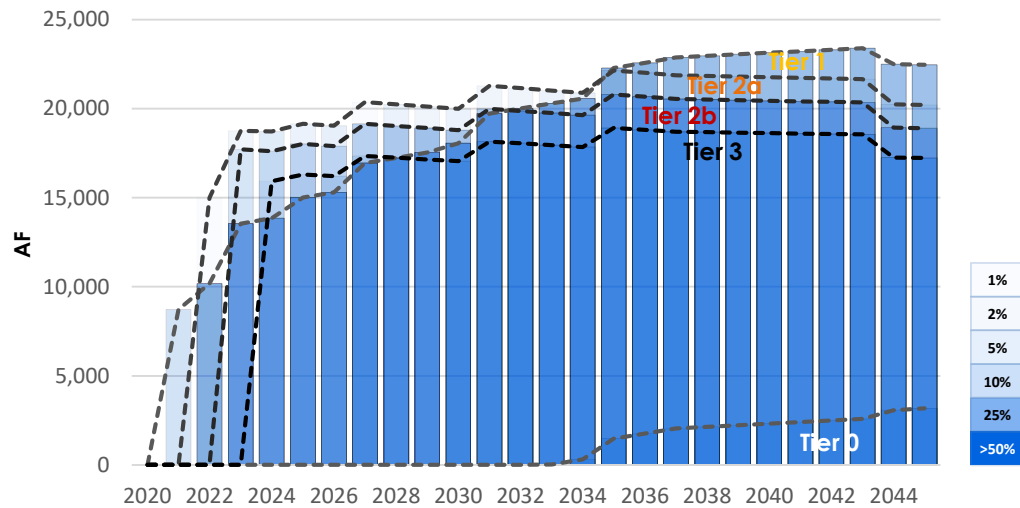
Figure 8 NIA Recovery Volume and Associated Probabilities

The potential maximum recovery volume increases through the near- and mid-term (**Table 8**). After 2035, NIA recovery volumes are reduced in collation with M&I firming. The Arizona Water Settlements Act stipulated a portion of the NIA pool received by tribes to be firmed to the extent of the M&I pool with the remainder keeping the NIA Priority status. As a result, when there is firming for the M&I pool, the NIA pool firming is limited by the M&I pool firming.

Table 8 Maximum Annual Recovery Volume for the NIA Priority Pool, by Shortage Tier and Planning Period

Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
0	0	1,500	3,200
1	15,300	22,300	23,400
2a	19,200	22,100	22,000
2b	18,000	20,800	20,700
3	16,300	18,900	18,800

M&I

Modeling results for CAP M&I users show recovery probabilities and the potential maximum recovery volume through the planning period (**Figure 9**).
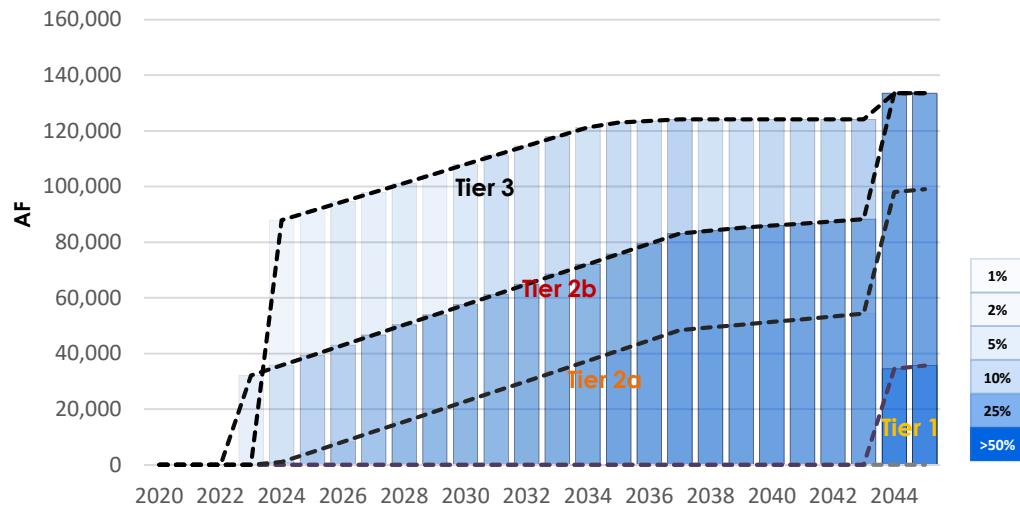
Figure 9 M&I Recovery Volume and Associated Probabilities

The potential maximum recovery volumes increase through the planning period (**Table 9**). The M&I pool is firmed to 100% through 2026 and is capped at 20% of the projected M&I use throughout the remainder of the planning period. In the near-term, there is no recovery in Tier 0.

Table 9 Maximum Annual Recovery Volume for the M&I Priority Pool, by Shortage Tier and Planning Period

Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
0	0	0	0
1	0	0	35,700
2a	8,300	41,100	99,100
2b	43,000	75,800	133,600
3	94,600	123,000	133,600

During discussions regarding risk, RPAG members indicated a clear desire for recovery planning efforts to address the highest volume of recovery, even if low in probability, to ensure that plans covered the greatest level of impact. Those maximum volumes, based on a Tier 3 shortage, result in the total intrastate recovery of up to 114,400 AF in the near-term, 146,900 AF in the mid-term and 160,100 AF in the long-term (**Table 10**).The implications for recovery of these volumes is discussed in the next section.

Table 10 Maximum Annual Recovery Volume

AWBA Firming Responsibility	Maximum Annual Volume (AF)		
	2021-2026	2027-2035	2036-2045
Indian NIA	19,200	22,300	23,400
On-River	600	1,600	3,100
M&I	94,600	123,000	133,600
Total Intrastate	**114,400**	**146,900**	**160,100**

# Appendix E – Assumptions for Full CAP Build-Out by 2045

1. **Total Deliveries:** CAP deliveries begin at approximately 1.66 MAF at the beginning of the projection period (2021), declining to 1.63 MAF at the end of the planning period before CAP system losses. There are no reductions due to 2007 Guidelines or LBDCP.
2. **CAP System Losses**: Assumes 75,000 AFY losses due to evaporation and transmission, across the entire projection period.
3. **P3 Priority**:   Assumes continued full utilization of P3 contracts by Indian and M&I users across the entire projection period (68,400 AFY).
4. **Indian Priority, used by M&I**:   Assumes the White Mountain Apache Tribe's Water Settlement is enforceable by 2023. The Indian priority allocation (1,218 AFY) and NIA priority allocation (23,782 AFY) is leased to M&I users in 2023.
5. **Indian Priority, used by Indians**:   Assumes full utilization of all remaining Indian Priority water by Indian users, after leases and exchanges have been subtracted.
6. **M&I Priority, used by M&I**:   By 2045, assumes full utilization of M&I subcontracts (totaling 620,678 AFY). Also assumes full utilization of former Hohokam assignment water (47,303 AFY) in 2044 - 2045 after it converts from NIA priority.
   a. **M&I Priority, allocated to Indians**:   The San Carlos Apache Tribe's allocation includes 18,145 AFY that is M&I Priority. There is full utilization of this allocation currently though a 12,500 AFY lease by Scottsdale and 5,645 AFY lease by Freeport-Morenci.
7. **NIA Priority, used by M&I**:   Assumes the first round of currently unallocated NIA water (46,629 AF) is allocated to M&I users within the CAP Service Area in 2022 with 44,914 AF taken in 2022 and the remainder of 1,715 AF taken in 2023. Assumes the second reallocation round (49,666 AF) has 17,333 AF taken in 2025 along with 6,374 AF of the original 15,000 AF of water providers serving land in Central Arizona Irrigation and Drainage District and Maricopa-Stanfield Irrigation and Drainage District. The remainder of the 15,000 AF (8,626 AF) and 17,333 AF reserved for outside the CAP Service Area are assumed to be allocated in 2030. Of the White Mountain Apache Tribe allocation, the Indian priority allocation (1,218 AFY) and NIA priority allocation (23,782 AFY) is leased to M&I users starting in 2023.
8. **NIA Priority, used by Indians**:   Assumes full utilization of all remaining NIA pool water by Indian users (GRIC and Tohono O'odham), after long-term leases and exchanges have been subtracted. Assumes the remaining pool volume reserved for future Indian Settlements (43,518 AF) is allocated and fully utilized by Indian users as follows – Hualapai 4,000 AF in 2025 with the remaining amount (39,518 AF) allocated in three rounds in 2027, 2031 and 2035.
9. **Ag Settlement Pool**:   Assumes tiered Agricultural Settlement Pool allocation with the step down to 225,000 AF in 2024.
10. **Other Excess**:   The projected Other Excess pool represents the residual CAP delivery supply after long-term contract and Ag Pool demands are fulfilled annually.

Appendix F – Planning Scenario Probability Results

As described in Section 5, for this Update two different Upper Basin demand projections were considered—the demand projection included in the CRSS model, and a scenario using a 15% reduction to that CRSS demand projections---and two different hydrologies---Direct Natural Flow and Stress Test---were evaluated.

A chart of annual probabilities, and a table of the probability of dropping below defined Lake Mead Elevations, is shown below for each scenario. These two together provide insight into the level of risk associated with future hydrologic conditions.
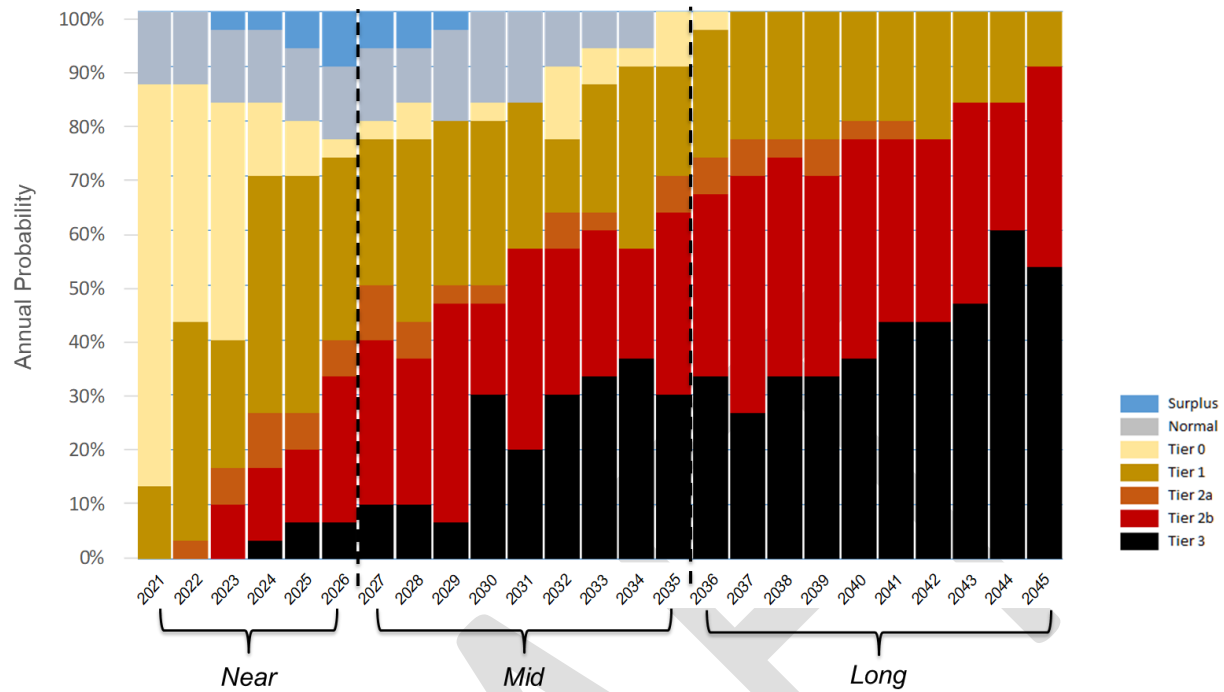
DNF "As-Is"
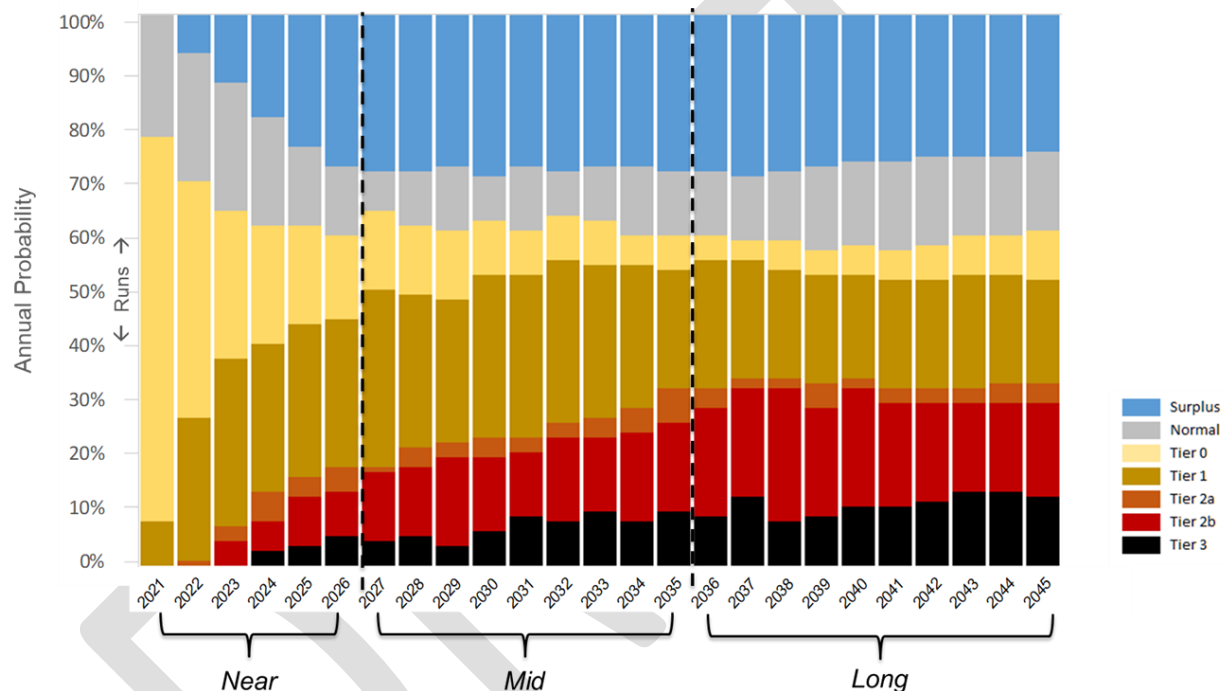
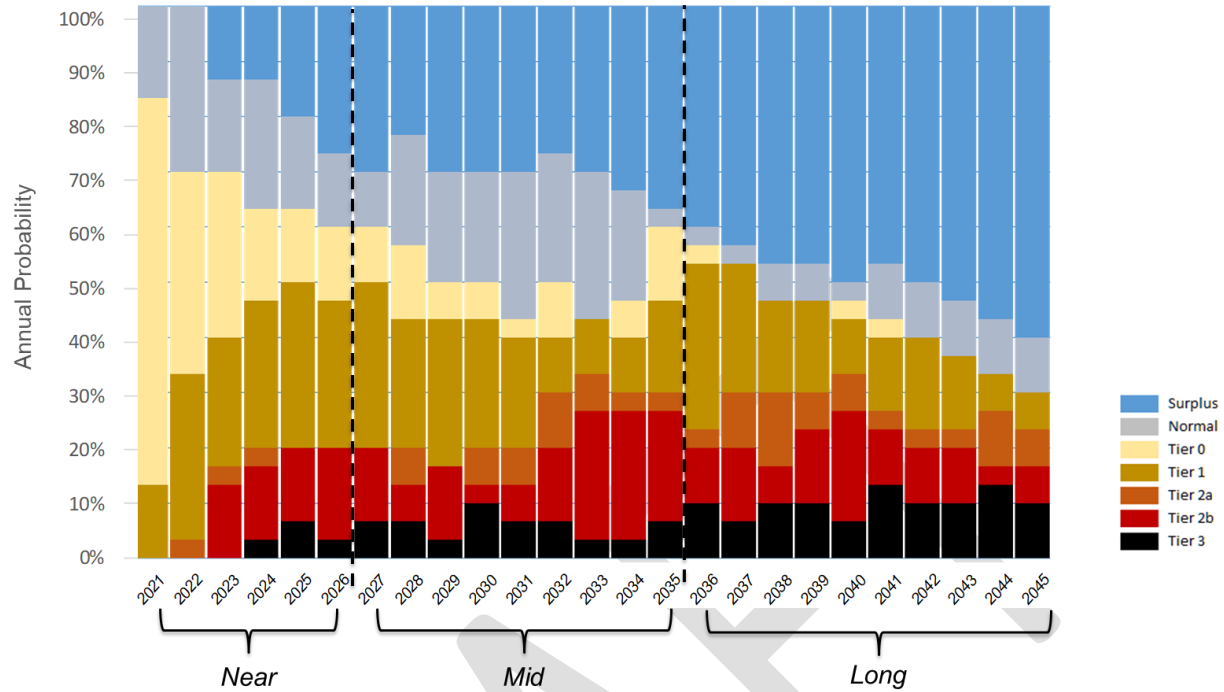| Probability of Dropping Below Defined Lake Mead Elevations at Least Once During a Planning Period: DNF "As-Is"				
Lake Mead Elevation	Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
<= 1,090'	Tier 0 or greater	86%	75%	73%
<= 1,075'	Tier 1 or greater	55%	71%	68%
<=1,050'	Tier 2a or greater	22%	47%	50%
<= 1,045'	Tier 2b or greater	17%	44%	49%
<= 1,025'	Tier 3	7%	25%	34%

DNF 15% Upper Basin Adjustment
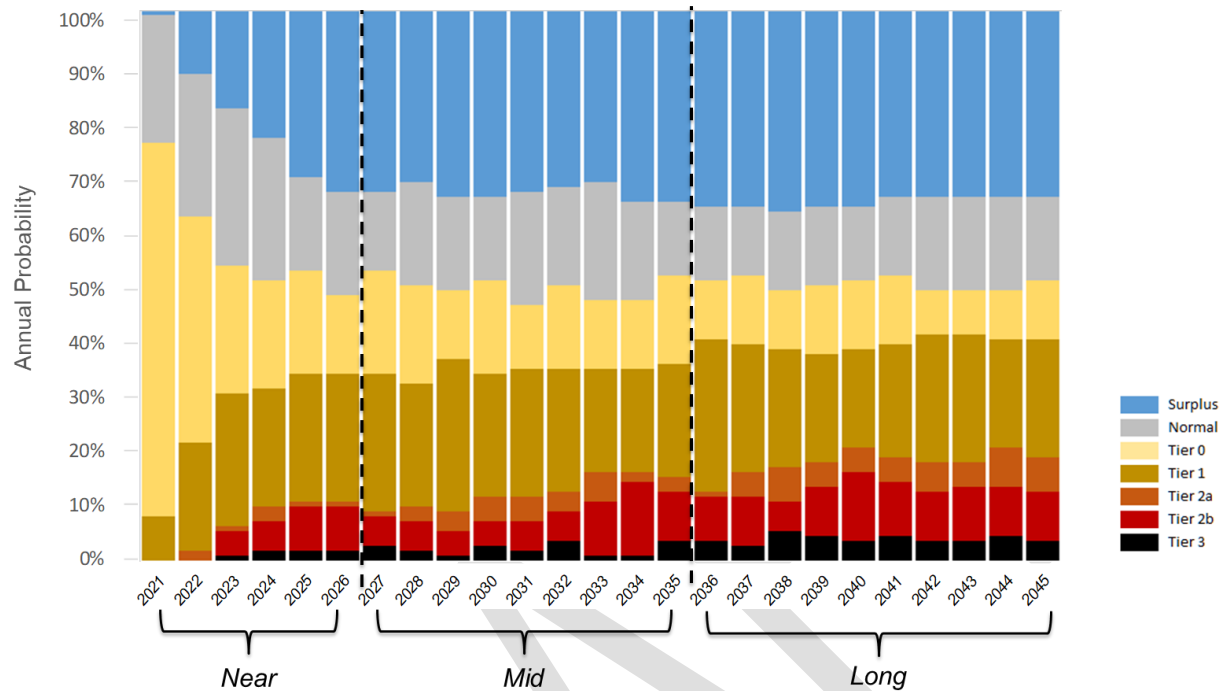
Probability of Dropping Below Defined Lake Mead Elevations at Least Once During a Planning Period: DNF 15% Upper Basin Adjustment				
Lake Mead Elevation	Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
<= 1,090'	Tier 0 or greater	81%	71%	68%
<= 1,075'	Tier 1 or greater	50%	59%	57%
<=1,050'	Tier 2a or greater	15%	23%	35%
<= 1,045'	Tier 2b or greater	13%	19%	33%
<= 1,025'	Tier 3	5%	8%	21%

Stress Test "As-Is"

Probability of Dropping Below Defined Lake Mead Elevations at Least Once During a Planning Period: Stress Test "As-Is"				
Lake Mead Elevation	Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
<= 1,090'	Tier 0 or greater	97%	100%	100%
<= 1,075'	Tier 1 or greater	77%	100%	100%
<=1,050'	Tier 2a or greater	47%	87%	100%
<= 1,045'	Tier 2b or greater	40%	83%	100%
<= 1,025'	Tier 3	10%	63%	90%

Stress Test 15% Upper Basin Adjustment

Probability of Dropping Below Defined Lake Mead Elevations at Least Once During a Planning Period: Stress Test 15% Upper Basin Adjustment				
Lake Mead Elevation	Tier	Near (2021-2026)	Mid (2027-2035)	Long (2036-2045)
<= 1,090'	Tier 0 or greater	90%	83%	57%
<= 1,075'	Tier 1 or greater	67%	80%	57%
<=1,050'	Tier 2a or greater	27%	47%	53%
<= 1,045'	Tier 2b or greater	27%	33%	50%
<= 1,025'	Tier 3	10%	17%	43%